

JONES DAY

51 LOUISIANA AVENUE, N.W. • WASHINGTON, D.C. 20001.2113
TELEPHONE: +1.202.879.3939 • FACSIMILE: +1.202.626.1700

DIRECT NUMBER: (202) 879-3630
BOLCOTT@JONESDAY.COM

May 13, 2016

VIA ELECTRONIC FILING

Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street S.W.
Washington D.C. 20554

**Re: Oral *Ex Parte* Notice
GN Docket No. 14-177, IB Docket Nos. 15-256 and 97-95;
RM-11664; and WT Docket No. 10-112**

Dear Ms. Dortch:

On May 11, 2016, representatives of The Boeing Company (“Boeing”) met with staff of the Office of Engineering and Technology (“OET”) to discuss the above-referenced proceeding and, more specifically, the potential for co-primary spectrum sharing between the proposed Upper Microwave Flexible Use (“UMFU”) service and next-generation broadband satellite communications systems in the 37.5-40.0 GHz band. Participating in the meeting on behalf of OET were Julius Knapp, Ronald Repasi, Walter Johnston, Mark Settle, and Michael Ha. Participating on behalf of Boeing were Robert Vaughan, Alexander Epshteyn, Carlos Nalda, and the undersigned, with Bruce Chesley, Audrey Allison, and Scott Mills also participating by phone.

The discussion tracked closely with the attached talking points and technical presentation. Boeing also explained during the meeting that it is developing a non-geostationary satellite orbit (“NGSO”) satellite system that requires access to the entire fixed-satellite service (“FSS”) allocation in the V-band to provide low-latency and very high data-rate broadband services.

Boeing emphasized during the meeting that its technical conclusions regarding the significant potential for spectrum sharing in the 37.5-40.0 GHz band are preliminary and Boeing continues to study the issues in order to refine its assumptions and conclusions. Boeing believes, however, that spectrum sharing between UMFU and broadband satellite systems – particularly NGSO FSS systems – is achievable in the 37.5-40.0 GHz band as long as reasonable measures are adopted by the Commission to facilitate co-frequency operations. Specific measures to facilitate co-primary spectrum sharing are identified in the attachments.

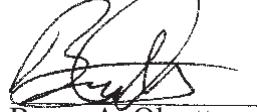
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Boeing's technical analysis regarding the potential for spectrum sharing in the 37.5-40.0 GHz band employed a UMFU base station EIRP limit of 65 dBm, which Boeing gleaned from a technical paper submitted by Straight Path Communications,¹ and which is 3 dB higher than the 62 dBm (1640 watts) power limit for base station-mobile operations proposed by the Commission in the *Notice of Proposed Rulemaking* in this proceeding.² Several 5G proponents recently filed a letter with the Commission requesting, without technical analysis or link budgets, an even greater increase in the permissible UMFU base station power level to 75 dBm EIRP.³ Boeing believes that such an increase is inconsistent with the documented operational range of contemplated 5G applications,⁴ and would substantially impair the ability of broadband satellite communications systems to share spectrum with UMFU networks in the 37.5-40.0 GHz band.

Boeing is holding conference calls with signatories to the recent letter and other 5G proponents to discuss Boeing's preliminary findings regarding spectrum sharing in the 37.5-40.0 GHz and to inquire about the technical basis for their request for higher power limits. Boeing will communicate further with the Commission on the outcome of these discussions.

Thank you for your attention to this matter. Please contact the undersigned if you have any questions.

Sincerely,



Bruce A. Olcott
Counsel to The Boeing Company

Attachments

¹ See Comments of Straight Path Communications, Inc., on the Petition for Rulemaking of the Fixed Wireless Communications Coalition to Create Service, RM-11664 (Jan. 5, 2015).

² See Use of Spectrum Bands Above 24 GHz For Mobile Radio Services, et al., GN Docket No. 14-177, *Notice of Proposed Rulemaking*, FCC 15-138, ¶ 274 (Oct. 23, 2015) (explaining that the Commission's proposed base station power limit is based on "the proposed deployment and service scenarios of mmW mobile broadband service").

³ See Ex Parte Filing of Verizon, Qualcomm Incorporated, Nokia, Samsung Electronics America, Intel Corporation, and Ericsson Inc., GN Docket No. 14-177 (April 21, 2016).

⁴ A higher power for UMFU base stations also seems in conflict with the basic principle of terrestrial network architecture that the limiting range is the return path from a lower-power user terminal. Increasing base station transmit power to 75 dBm would likely extend the geographic range of base stations beyond the point where user terminals could reliably respond.

Broadband Satellite Services in the 37/39 GHz Bands

The Boeing Company

May 2016

- Next generation satellite networks can provide high capacity broadband service to end users in *all* locations in the United States and are therefore critical to ensure the universal availability of broadband to all Americans, as required by the Communications Act
 - Section 151 of the Communications Act mandates a “rapid, efficient, *Nation-wide*, and world-wide wire and radio communication service” and Section 307(b) requires “the equitable distribution of radio service throughout the nation”
- Boeing is developing a non-geostationary satellite network that requires access to the entire V-band to provide low latency and very high data rate broadband services
 - Broadband data usage is asymmetrical – most users download far more than they upload. Satellites therefore need at least as much downlink spectrum as uplink.
 - The V-band was originally balanced between satellite uplink and downlink:
 - 37.5-42.5 GHz (5 GHz) is globally allocated for space-to-Earth
 - 47.2-50.2 and 50.4-51.4 GHz (4 GHz) are allocated for Earth-to-space
- The “soft segmentation” approach adopted more than a decade ago for the 37.5-42.5 GHz band disrupts this balance and leaves V-band satellite spectrum very asymmetrical in the wrong direction
 - It is therefore necessary to ensure that broadband satellite end user receivers can effectively use the 37.5-40.0 GHz band to receive downlink transmissions
- The following measures could help to ensure that broadband satellite networks can share with other services in the 37.5-40.0 GHz portion of the V-band:
 - Lift § 25.202(a)(1) restriction on end user receivers in the 37.5-40.0 GHz band
 - Permit satellite networks to transmit at higher pfd levels in the 37.5-40.0 GHz
 - Existing limits (§ 25.208(r)) were intended to protect long-haul fixed links using older technologies and exceed what is needed to adequately protect short range 5G mobile services or the fixed link services that exist today
 - Require 5G mobile services to employ beam forming and power control
 - Require 5G network operators to disclose base station locations
 - Restrict 5G base station transmitter height and maximum power levels
- The FCC should also allocate the 42.0-42.5 GHz band for the fixed satellite service, which is well positioned to protect adjacent radio astronomy services in that range



Space and Intelligence Systems
Boeing Satellite Systems International, Inc



37.5-40.0 GHz Satellite & Terrestrial Spectrum Use

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Agenda

Boeing Satellite Systems

- Overview – Spectrum Sharing Can be Achieved
- **Satellite to Mobile**
 - Satellite to Mobile Handset
 - Satellite to Base Station
- **Mobile Handset to Satellite Receivers**
- **Base Station to Satellite Receivers**
- Path Forward for 37.5-40.0 GHz and Recommendations

Overview – Spectrum Sharing Can be Achieved

▪ 37.5 – 40.0 GHz

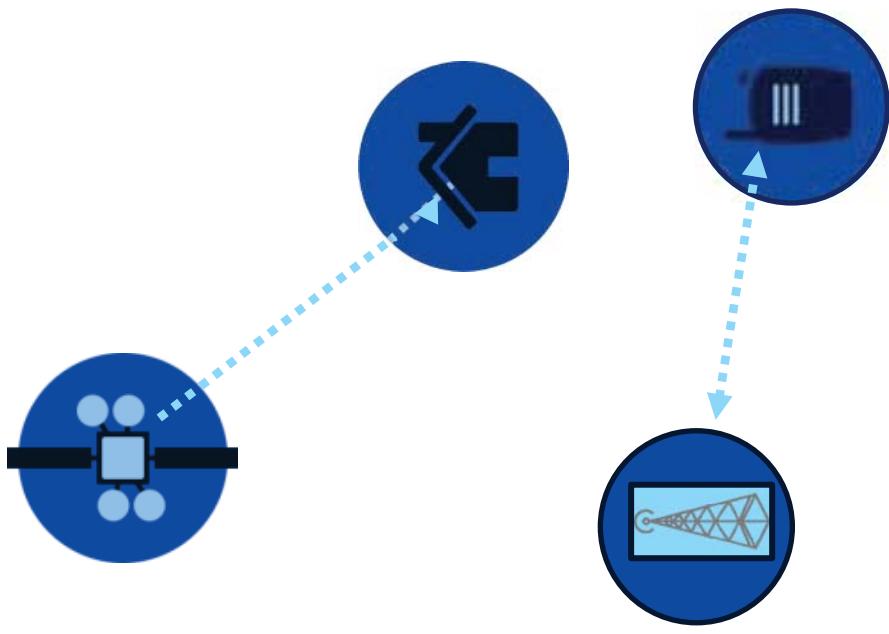
- FSS satellite downlink allocation (gateway only)
- Proposed use by terrestrial 5G mobile

▪ Achieve shared usage between:

- 5G base stations and handsets
- High-capacity satellites and satellite receivers

▪ Measures contributing to shared use:

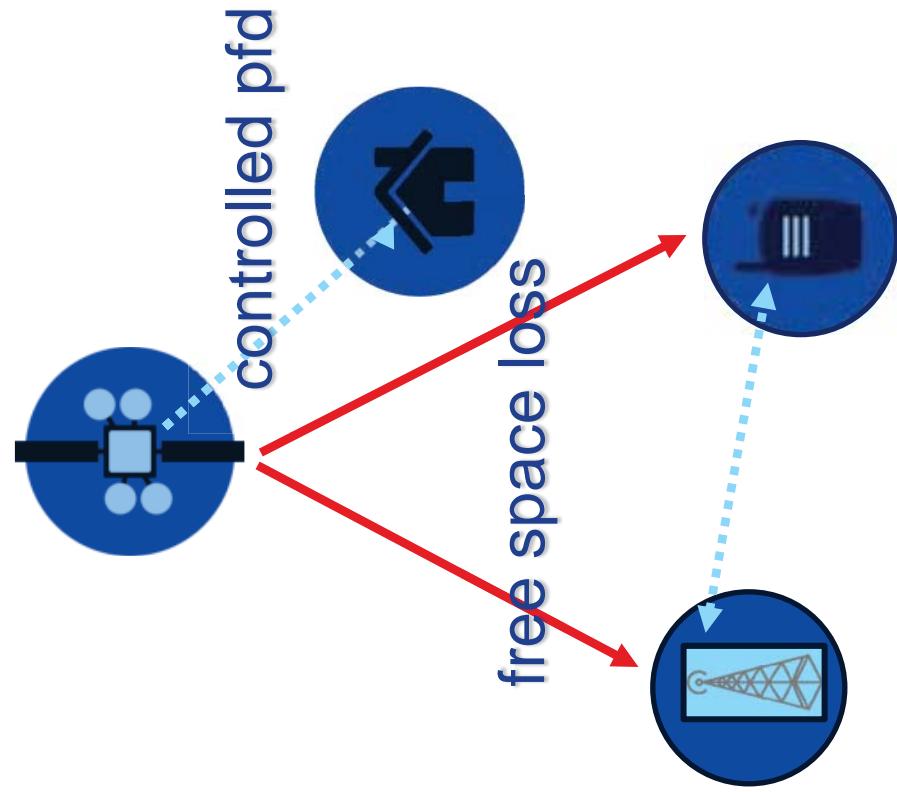
- 5G beam forming and power control
- Highly directional satellite receivers using nulling
 - Results in significant angular separation between 5G transmissions and satellite receiver reception paths
- Limit on 5G base station height and power level
- Satellite transmissions at ITU pfd levels



Interference From Satellite into Mobile Services

Boeing Satellite Systems

■ Must control harmful interference



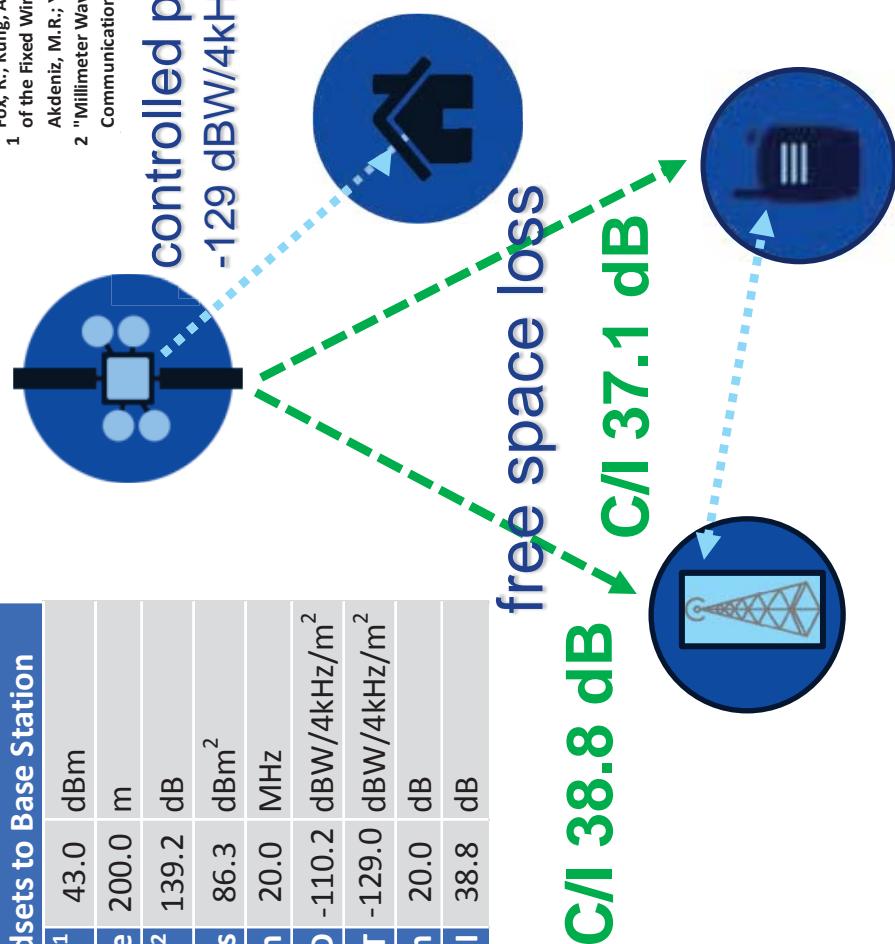
- From satellites
 - into base stations
 - into mobile handsets
- From mobile handsets
 - into satellite receivers
- From base stations
 - into satellite receivers

Link Analysis: Satellite to Mobile

Boeing Satellite Systems

Mobile Handsets to Base Station	
EIRP ¹	43.0 dBm
Max Distance	200.0 m
Path Loss ²	139.2 dB
Spreading Loss	86.3 dBm ²
Bandwidth	20.0 MHz
PFD from SAT	-110.2 dBW/4kHz/m ²
PFD Rx Isolation	-129.0 dBW/4kHz/m ²
WC Rx Isolation	20.0 dB
C/I	38.8 dB

- 1 Fox, R.; Kung, A; "Comments of Straight Path Communications, Inc." Petition for Rulemaking of the Fixed Wireless Communications Coalition to Create Service, RM-11664, January 5, 2015.
2 Akdeniz, M.R.; Yuanpeng Liu; Samimi, M.K.; Zhu Sun; Rangan, S.; Rapaport, T.S.; Erkip, E., "Millimeter Wave Channel Modeling and Cellular Capacity Evaluation," Selected Areas in Communications, IEEE Journal on , vol.32, no.6, pp.1164-1179, June 2014

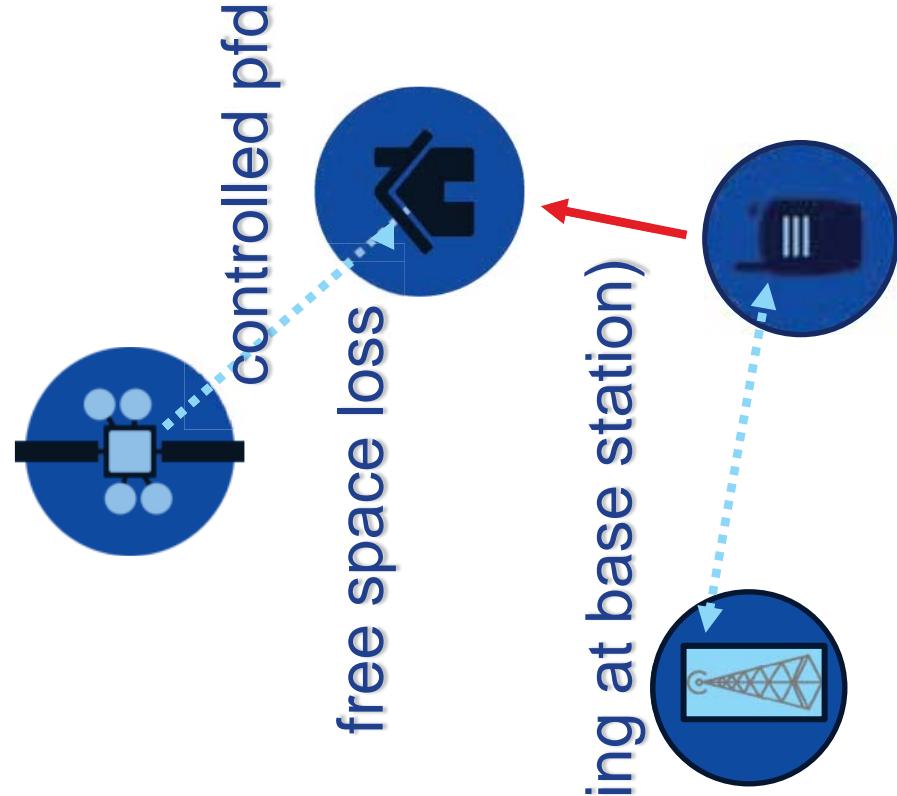


No significant impact on 5G systems resulting from satellite downlinks even at 12 dB higher PFD level identified by ITU

Interference from Handsets into Satellite Receivers

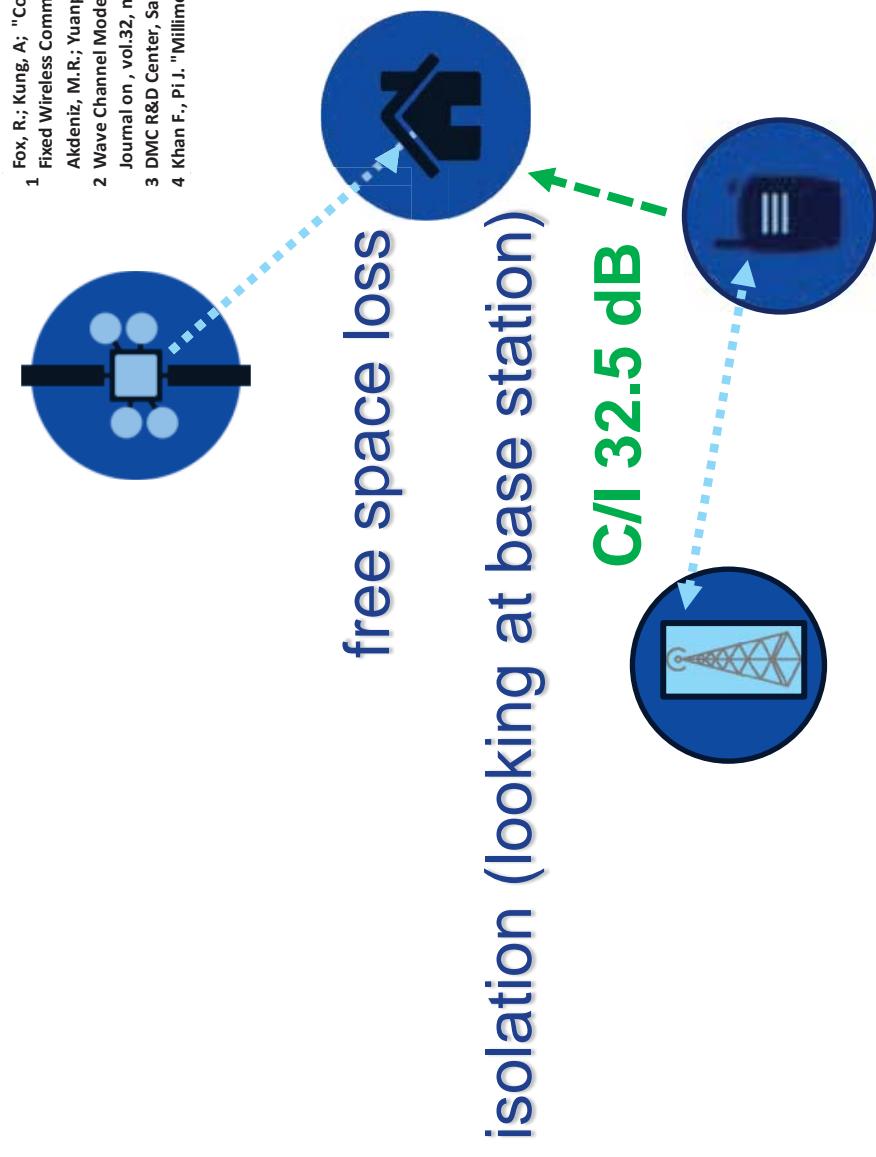
Boeing Satellite Systems

■ Must control harmful interference

- From satellites
 - into base stations
 - into mobile handsets
 - From mobile handsets
 - into satellite receivers
 - From base stations
 - into satellite receivers
- 

Link Analysis: Handset to Satellite Receivers

Boeing Satellite Systems



- 1 Fox, R.; Kung, A.; "Comments of Straight Path Communications, Inc." Petition for Rulemaking of the Fixed Wireless Communications Coalition to Create Service, RM-11664, January 5, 2015.
- 2 Aldeniz, M.R.; Yuanyang Liu; Samimi, M.K.; Shu Sun; Rangan, S.; Rappaport, T.S.; Erkip, E., "Millimeter Wave Channel Modeling and Cellular Capacity Evaluation," Selected Areas in Communications, IEEE Journal on , vol.32, no. 6, pp.1164,1179, June 2014
- 3 DMC R&D Center, Samsung Electronics Co., Ltd. "5G Vision", February 2015.
- 4 Khan F., Pi J. "Millimeter-wave Mobile Broadband: Unleashing 3-300GHz Spectrum", March 28, 2011.

Mobile Handset to Satellite Receiver		
EIRP ¹	43.0	dBm
Avg Distance	100.0	m
Path Loss ²	130.4	dB
Spreading Loss	77.5	dBm ²
Bandwidth	20.0	MHz
PFD	-101.5	dBW/4kHz/m ²
PFD from SAT	-129.0	dBW/4kHz/m ²
Avg Tx Isolation ^{3,4}	10.0	dB
Avg Rx Isolation	50.0	dB
C/I	32.5	dB

5G handset and satellite receiver beam forming provide inherent isolation and sharing is possible based on initial analysis

Link Analysis: Handset to Satellite Receivers

Boeing Satellite Systems

■ Transmit isolation:

- 5G handsets implement beam forming capability
 - Directs beam towards closest base station
 - Average angular separation above 90°
 - Additional study warranted
- ## ■ Receive isolation:
- Satellite receiver is highly directional
 - Minimum elevation angle of 45 degrees toward satellite sets angular separation

Mobile Handset to Satellite Receiver
EIRP ¹
Avg Distance
Path Loss ²
Spreading Loss
Bandwidth
PFD
PFD from SAT
Avg Tx Isolation ^{3,4}
Avg Rx Isolation
C/I

**Initial results are promising
with further analysis planned**

¹ Fox, R.; Kung, A; "Comments of Straight Path Communications, Inc." Petition for Rulemaking of the Fixed Wireless Communications Coalition to Create Service, RM-11664, January 5, 2015.

² Akdeniz, M.R.; Yuanpeng Liu; Samimi, M.K.; Shu Sun; Rangan, S.; Rappaport, T.S.; Erkip, E., "Millimeter Wave Channel Modeling and Cellular Capacity Evaluation," Selected Areas in Communications, IEEE Journal on , vol.32, no.6, pp.1164-1179, June 2014

³ DMC R&D Center, Samsung Electronics Co., Ltd. "5G Vision", February 2015.

⁴ Khan F., P.I.J. "Millimeter-wave Mobile Broadband: Unleashing 3-300GHz Spectrum", March 28, 2011.

Interference from Base Station into Satellite Receivers

■ Must control harmful interference

- From satellites
 - into base stations
 - into mobile handsets
 - From mobile handsets
 - into satellite receivers
 - From base stations
 - into satellite receivers
-
- controlled pfd
- free space loss
- isolation (looking at mobile users)

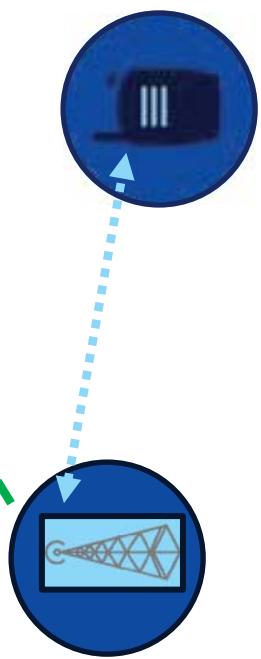
Link Analysis: Base Station to Satellite Receivers

Boeing Satellite Systems



C/I 24.1 dB

isolation (looking at mobile users)



Base Station to Satellite Receiver	
EIRP ¹	65.0 dBm
Avg Distance	100.0 m
Path Loss ²	130.4 dB
Spreading Loss	77.1 dBm ²
Bandwidth	50.0 MHz
PFD	-83.1 dBW/4kHz/m ²
PFD from SAT	-129.0 dBW/4kHz/m ²
Avg Tx Isolation ^{3,4}	20.0 dB
Rx Isolation	50.0 dB
C/I	24.1 dB

Interference from 5G base stations potentially manageable with appropriate beam forming techniques

- Fox, R.; Kung, A; "Comments of Straight Path Communications, Inc." Petition for Rulemaking of the Fixed Wireless Communications Coalition to Create Service, RM-11664, January 5, 2015.
Akdeniz, M.R.; Yuanpeng Liu; Shu Sun; Rangan, S.; Rappaport, T.S.; Erkip, E., "Millimeter Wave Channel Modeling and Cellular Capacity Evaluation," Selected Areas in Communications, IEEE Journal on , vol.32, no.6, pp.1164-1179, June 2014
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4 Khan F., Pi J. "Millimeter-wave Mobile Broadband: Unleashing 3-300GHz Spectrum", March 28, 2011.

Link Analysis: Base Station to Satellite Receivers

Boeing Satellite Systems

■ Transmit isolation:

- Base stations employ beam forming to users
- Stationary antennas allow for use of advanced sectorized phased array
- Further study necessary to characterize transmit isolation

■ Receive isolation:

- Satellite terminal is highly directional
- Nulling capability enables higher sidelobe suppression toward base stations

Base Station to Satellite Receiver	
EIRP ¹	65.0 dBm
Avg Distance	100.0 m
Path Loss ²	130.4 dB
Spreading Loss	77.1 dBm ²
Bandwidth	50.0 MHz
PFD	-83.1 dBW/4kHz/m ²
PFD from SAT	-129.0 dBW/4kHz/m ²
Avg Tx Isolation ^{3,4}	20.0 dB
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**Initial results are promising
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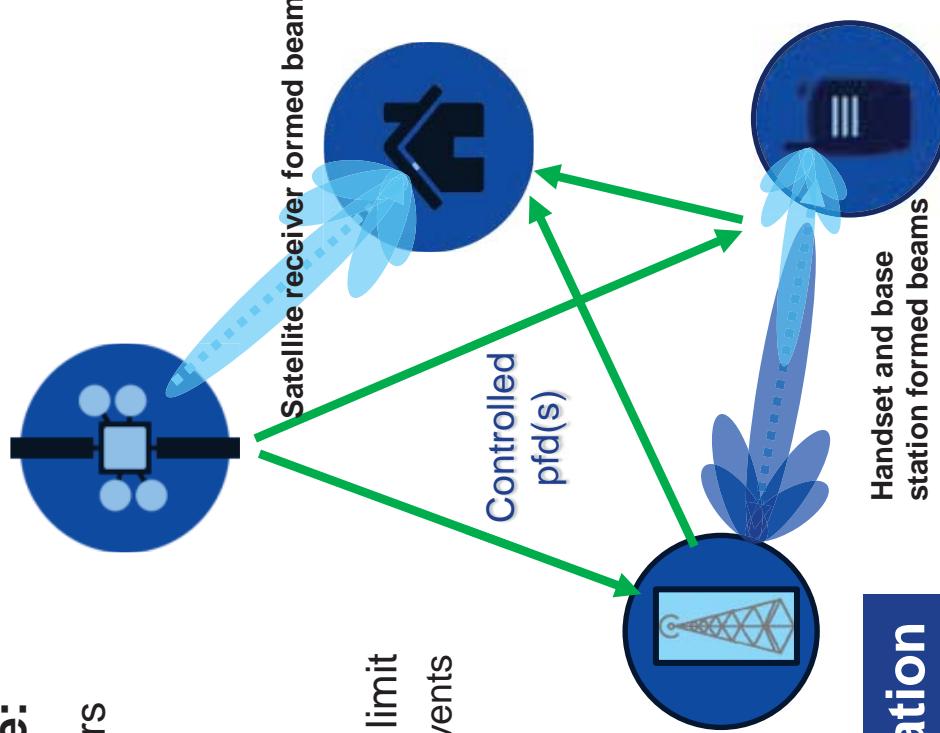
⁴ Khan F., Pi J., "Millimeter-wave Mobile Broadband: Unleashing 3-300GHz Spectrum", March 28, 2014.

Path forward for 37.5 - 40.0 GHz – Recommendations

Boeing Satellite Systems

▪ Measures to ensure efficient spectrum use:

- Remove prohibition on satellite end user receivers
 - Allow unrestricted deployment of satellite receivers
- Permit satellite downlinks at ITU PFD levels
- Require mobile services to use beam forming
 - Would facilitate both inter- and intra-service sharing
- Adopt base station transmitter height and power limit
 - Such limits reduce line of sight (LOS) interference events into upward facing satellite user terminals
 - Such limits may also optimize 5G propagation and intra-service 5G sharing
- Require mobile services to use power control
 - Limits interference into LOS satellite user terminals
- Require disclosure of base station locations
 - Disclosure enables satellite user terminal nulling



Significant further study and consultation with wireless industry required